EA 05-0F6500
05-SCR-1-PM 14.96 to 15.94
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Highway 1 Soquel to Morrissey Auxiliary Lanes Project
Santa Cruz County, California

Location Hydraulic Study Report

Prepared for:

Caltrans

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Submitted to:
California Department of Transportation

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

Han-Bin Liang, Ph.D., P.E.
Registered Civil Engineer

9/16/2008
Date

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Executive Summary

The purpose of the Highway 1 Soquel to Morrissey Auxiliary Lanes Project is to improve highway traffic flow caused by traffic weaving and merging operations on Highway 1 (State Route 1) between Soquel Drive and Morrissey Boulevard. The Soquel to Morrissey Auxiliary Lanes Project consists of adding 1 mile (1.6 km) of auxiliary lanes along Highway 1 in Santa Cruz County, California. The alternatives under consideration are a No-Build Alternative and Build Alternative.

The Soquel to Morrissey Auxiliary Lanes Project encompasses four culvert creek crossings: Arana Gulch and its three tributaries. The Arana Gulch 72-inch (1800-mm) concrete arch culvert is at Station 171+03. The tributaries to Arana Gulch cross Highway 1 through a 48-inch (1200-mm) concrete culvert at Station 175+98, a 4-feet by 4-feet (1200-mm by 1200-mm) reinforced concrete box culvert at Station 177+92, and a 30-inch (750-mm) reinforced concrete pipe culvert at Station 183+01.

The Arana Gulch crossing is within Federal Emergency Management Agency delineated 100-year floodplains but the Soquel to Morrissey Auxiliary Lanes Project will not longitudinally encroach on the floodplains. No culverts will be extended as part of the Soquel to Morrissey Auxiliary Lanes Project since the culvert entrances and outfalls are beyond the roadway widening. Preliminary calculations indicate that the 4-feet by 4-feet (1200-mm by 1200-mm) reinforced concrete box culvert, a system tributary to Arana Gulch, at Station 177+92, is undersized and will need to be replaced with larger sizes (or parallel systems). These improvements are not within FEMA-delineated floodplains. The use of better end treatments, such as wingwalls and rock slope protection, will be considered at this crossing to improve hydraulics.

New longitudinal drainage systems will be proposed roughly parallel to the proposed retaining walls. The proposed retaining wall near and at the north end of the Arana Gulch crossing is within the 100-year base floodplain. In order to address the impacts from the loss of floodplain storage, mitigation measures will be proposed which may be accomplished by re-grading adjacent to the floodplain.

The Soquel to Morrissey Auxiliary Lanes Project will not pose an increased flooding risk. The increase in roadway runoff will be minimal, in comparison to the overall watershed of the creek (0.6%). In addition, the Soquel to Morrissey Auxiliary Lanes Project design goal will be to maintain pre-construction storm water flows by metering or detaining these flows to pre-construction rates prior to discharge to a receiving water body or Municipal Separate Storm Sewer System. Therefore, there will be no substantial change in the water surface elevation to the identified floodplain area due to the proposed widening. There may be traffic interruption on Highway 1 due to the base flood but traffic may utilize the local roads for a detour route with access points at the Morrissey Boulevard and Soquel Drive intersections of Highway 1. The base flood is a flood which has a one percent chance of occurrence in any given year (also known as a 100-year flood).

It is anticipated that the Soquel to Morrissey Auxiliary Lanes Project will impact the natural and beneficial floodplain values at Arana Gulch. The proposed widening of the roadway will encroach transversely on the Arana Gulch floodplain. Environmental impacts will be a result of construction activities and can be minimized with Best Management Practices (BMPs) measures such as revegetation or protection with Environmentally Sensitive Area Fencing, Implementation of Best Management Practices; compliance with the anticipated permit conditions and requirements of the Soquel to Morrissey Auxiliary Lanes Project will also help minimize impacts to natural and beneficial floodplain values.

The Project Team is proposing drainage design improvements to accommodate increased peak storm water runoff from the roadway. Appropriate Best Management Practices are proposed to minimize storm water impacts, both permanently and during construction, by reducing storm water runoff velocities and promoting infiltration. Some examples of proposed Best Management Practices are Concrete Washout facilities or Dewatering specifications during construction. The use of better end treatments, such as wingwalls and rock slope protection, will be considered at major culvert crossings with proposed drainage work (e.g. at the tributary to Arana Gulch at Station 177+92) to improve hydraulics. In addition, Treatment Best Management Practices being considered for the Soquel to Morrissey Auxiliary Lanes Project include Infiltration Devices, Biofiltration Strips, Wet Basins, Biofiltration Swales, Austin Sand Filters, Detention Devices, Delaware Filters, and Multi-Chambered Treatment Trains. Best Management Practices that are feasible for the Soquel to Morrissey Auxiliary Lanes Project include Biofiltration Strips, Biofiltration Swales, and Detention Devices. The consideration of Best Management Practices at potential treatment locations are detailed in the Storm Water Data Report.

As mentioned previously, the goal of the Soquel to Morrissey Auxiliary Lanes Project is to improve traffic conditions for weaving and merging movements on Highway 1. The Soquel to Morrissey Auxiliary Lanes Project has considered practicable alternatives to minimize floodplain impacts while trying to accomplish its purpose. The Build Alternative will maintain the existing alignment and profile to minimize floodplain impacts, while also minimizing cost and achieving transportation goals.

1 PROJECT DESCRIPTION

The proposed project extends for a distance of 0.98 mile from the southbound Soquel Avenue off-ramp to the northbound Morrissey Boulevard on-ramp (post mile 14.96 to post mile 15.94) in the City of Santa Cruz, Santa Cruz County, California. Maps of the project vicinity and location are included below in Figures 1& 2.

1.1 Project Purpose

The purpose of the Soquel to Morrissey Auxiliary Lanes Project is to improve traffic conditions for lane-changing and merging movements on Highway 1 between Soquel Avenue and Morrissey Boulevard and improve pedestrian and bicycle access and safety.

1.2 Project Need

Identified needs include recurrent congestion from impeded lane-changing and merging movements, queuing traffic from the southbound bottleneck at the La Fonda Avenue overcrossing, and limited pedestrian and bicycle access crossing Highway 1 in the project area.

1.3 Alternatives

Two alternatives are under consideration: one Build Alternative and the No-Build Alternative.

1.3.1 Build Alternative

The Build Alternative would add one 12-foot-wide auxiliary lane from the Soquel Avenue on-ramp to the Morrissey Boulevard off-ramp in the northbound direction and extend a12-foot-wide lane from about 500 feet north of the La Fonda Avenue overcrossing to the Soquel Avenue off-ramp in the southbound direction, with 10-foot outside shoulders between the Soquel Avenue and Morrissey Boulevard interchanges. An auxiliary lane extends from the on-ramp of one interchange to the off-ramp at the next interchange and is designed to separate traffic movements entering and exiting the freeway from mainline traffic. It is not designed for use by through traffic. The project also would replace the La Fonda Avenue overcrossing.

A typical auxiliary lane would be constructed northbound from the Soquel Drive on-ramp to the Morrissey Boulevard northbound off-ramp (0.7 mile). On southbound Highway 1, the new outside lane being constructed with the State Route 1/ State Route 17 Merge Lanes Project would be extended from north of the La Fonda Avenue overcrossing to the Soquel Avenue exit ramp (0.3 mile). This lane would be "exit only" at Soquel Avenue, and the widening would eliminate the outside lane-drop north of La Fonda. No changes would be made to the Soquel Avenue or Morrissey Boulevard ramps. Retaining walls are proposed at several locations to reduce the amount of earthwork required, keep the improvements within the existing highway right-of-way and minimize impacts to wetlands and other waters of the U.S. Soundwalls found to be feasible and reasonable based on current cost estimates also are recommended.

Additionally, the La Fonda Avenue overcrossing would be replaced and widened to accommodate the proposed auxiliary lanes. The new bridge would provide for two 12-foot-wide traffic lanes, as well as five-foot-wide bicycle lanes and six-foot-wide pedestrian sidewalks in both directions.

The project also would demolish the existing La Fonda Avenue overcrossing and existing roadway shoulder, and require earthwork and fill and temporary easements for construction of the overcrossing replacement and a temporary pedestrian/bicycle crossing. Disposal will be in accordance with all applicable regulations at locations to be identified at the final design phase. There is no permanent right-of-way impact anticipated for this alternative. Temporary easements of City of Santa Cruz property and two privately owned properties would be required.

Local street improvements, including new five-foot-wide sidewalks, curb, and gutter on the north side of Rooney Street and Morrissey Boulevard between Elk Street and San Juan Avenue, also would be constructed. This work would include four accessible driveway approaches and four pedestrian ramps in compliance with the Americans with Disabilities Act.

1.3.2 No-Build Alternative

The No-Build Alternative would not address the project purpose and need but offers a basis for comparison with the Build Alternative. It assumes no major construction on Highway 1 through the project limits other than planned and programmed improvements and continued routine maintenance. The only planned and programmed improvement contained in the 2005 Regional Transportation Plan is the State Route 1/ State Route 17 Merge Lanes Project, which is currently under construction with completion set for fall 2008; it is considered as part of existing conditions for the Soquel to Morrissey Auxiliary Lanes Project. The Highway 1 High Occupancy Vehicle Lane Widening Project is also planned, but is not included in the No-Build Alternative, as it is not yet programmed and will not be completed by the 2015 opening year for the Soquel to Morrissey Auxiliary Lanes Project.

1.4 Geographical References

Project location and vicinity maps were based on maps from the United States Geological Survey (USGS):

- Santa Cruz, California. Map Version 1987. Map current as of 1994.
- Soquel, California. Map Version 1997. Map current as of 1994.

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) and flood profiles from the Flood Insurance Study (FIS) for Santa Cruz County and incorporated areas were reviewed for base flood elevations at the Arana Gulch crossing of Highway 1. The base flood is a flood which has a one percent chance of occurrence in any given year.

The vertical control for the elevations in the FIRM and FIS are based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The survey for this project is based on the North American Vertical Datum of 1988 (NAVD 88).

Using the Orthometric Height Conversion from the National Geodetic Survey website, the datum shift (from NAVD 88 to NGVD 29) was calculated based on the location of the crossing at Arana Gulch. The north latitude and west longitude was obtained from USGS Topographic Maps (2001). The Arana Gulch crossing is located at a latitude of 36°59'16" N and a longitude of 121°59'17" W. The datum shift at this location is 2.74 ft (0.834 m).

Elevations obtained from the FEMA were adjusted by adding the datum shift to convert from the NGVD 29 datum to the NAVD 88 datum. The base flood elevations at Arana Gulch were adjusted by adding 2.74 feet to convert from the NGVD 29 datum to the NAVD 88 datum. The base flood elevation upstream of the crossing of Highway 1 is 68 ft NAVD 88 (21 m) and the base flood elevation downstream of the crossing of Highway 1 is 49 ft (15 m).

1.5 Traffic

Ramp counts were conducted in 2001 and 2003 between Soquel Avenue to Morrissey Boulevard (2008). Traffic conditions are summarized for the existing condition (based on 2001 and 2003 data) and the projected condition (2015) in Table 1.

Table 1. Peak Hour Traffic Conditions (Existing and Projected 2015)

Measure of Effectiveness	Existing Conditions		Year 2015 Conditions			
			No-Build		Build	
	AM	PM	AM	PM	AM	PM
Average Travel Time (minutes)						
Northbound	0.81	0.81	0.81	0.81	1.34	0.71
Southbound	0.94	2.74	1.06	5.49	0.90	8.03
Average Speed (mph)						
Northbound	51	51	51	51	32	58
Southbound	60	22	53	10	62	7
Delay (minutes per vehicle)						
Northbound	0.12	0.14	0.12	0.14	0.64	0.05
Southbound	0.04	1.88	0.16	4.53	0	7.15
No. of Vehicle Trips (per hour)						
Northbound	4,459	3,991	4,742	4,744	4,830	4,750
Southbound	3,377	3,435	3,874	3,745	3,874	3,608
No. of Person Trips (per hour)						
Northbound	5,039	4,949	5,358	5,883	5,458	5,890
Southbound	3,917	3,985	4,494	4,419	4,494	4,257
Avg. Vehicle Occupancy (persons/vehicle)						
Northbound	1.13	1.24	1.13	1.24	1.13	1.24
Southbound	1.16	1.18	1.16	1.18	1.16	1.18
Density (pcpmpl)						
Northbound	40	38	40	36	52	27
Southbound	28	78	30	117	21	134
Level of Service						
Northbound	E	E	E	E	F	D
Southbound	D	F	D	F	C	F

Source: Highway 1 Soquel / Morrissey Auxiliary Lanes Traffic Operations Report, February 2008

1.6 Traffic Interruptions for Base Flood (Q_{100})

The base flood is a flood which has a one percent chance of occurrence in any given year (also known as a 100-year flood, or Q_{100}). Potential flooding conditions for the proposed Soquel to Morrissey Auxiliary Lanes Project were evaluated using the water surface elevation from the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Arana Gulch. Based on available data, there may be traffic interruptions on Highway 1 due to the base flood. The FIRM depicts the base flood overtopping Highway 1 at the Arana Gulch crossing with a base flood elevation of 68 ft (21 m) at the upstream side (see Section 2.2). Based on Project topography, the proposed roadway elevation is 68 ft (21 m). The roadway, in both directions of travel would experience traffic interruptions. Traffic could be re-directed to a detour via local roadways with ingress and egress points at the Morrissey Boulevard and Soquel Drive intersections.

1.7 Creeks, Streams, and River Crossings

Four waterways cross Highway 1 along the Soquel to Morrissey Auxiliary Lanes Project reach: Arana Gulch and three tributaries. These are the highway's direct receiving water bodies.

These four creek crossings were located from reviewing as-built record drawings, site visits, and the *Wetland Assessment Report* (2008). The crossing culvert at Station 171+03 for Arana Gulch was identified as a concrete arch culvert from field observations and the size was identified as a 72-inch (1800-mm) concrete culvert in the *Wetland Assessment*. The 48-inch (1,200-mm) concrete culvert for the tributary to Arana Gulch at Station 175+98 was not located during the field visit but was identified in the *Wetland Assessment Report* (2008). The 30-inch (750-mm) reinforced concrete pipe culvert for the tributary to Arana Gulch at Station 183+01 is outside of the area of improvement but within the Soquel to Morrissey Auxiliary Lanes Project limits. These creek crossings and their respective sizes are listed in Table 2, which also includes information on the creek crossing at Station 177+92, a 4 feet by 4 feet (1200 mm by 1200 mm) reinforced concrete box culvert.

Table 2. Creek Crossings

Waterway	Station	Culvert Size	
		Metric	English
Arana Gulch	171+03	1800 mm (height) concrete arch culvert	72" (height)concrete arch culvert
Tributary to Arana Gulch	175+98	1200 mm concrete culvert	48" concrete culvert
Tributary to Arana Gulch	177+92	1200 mm x 1200 mm reinforced concrete box culvert	4' x 4' reinforced concrete box culvert
Tributary to Arana Gulch	183+01	750 mm reinforced concrete pipe culvert	30” reinforced concrete pipe culvert

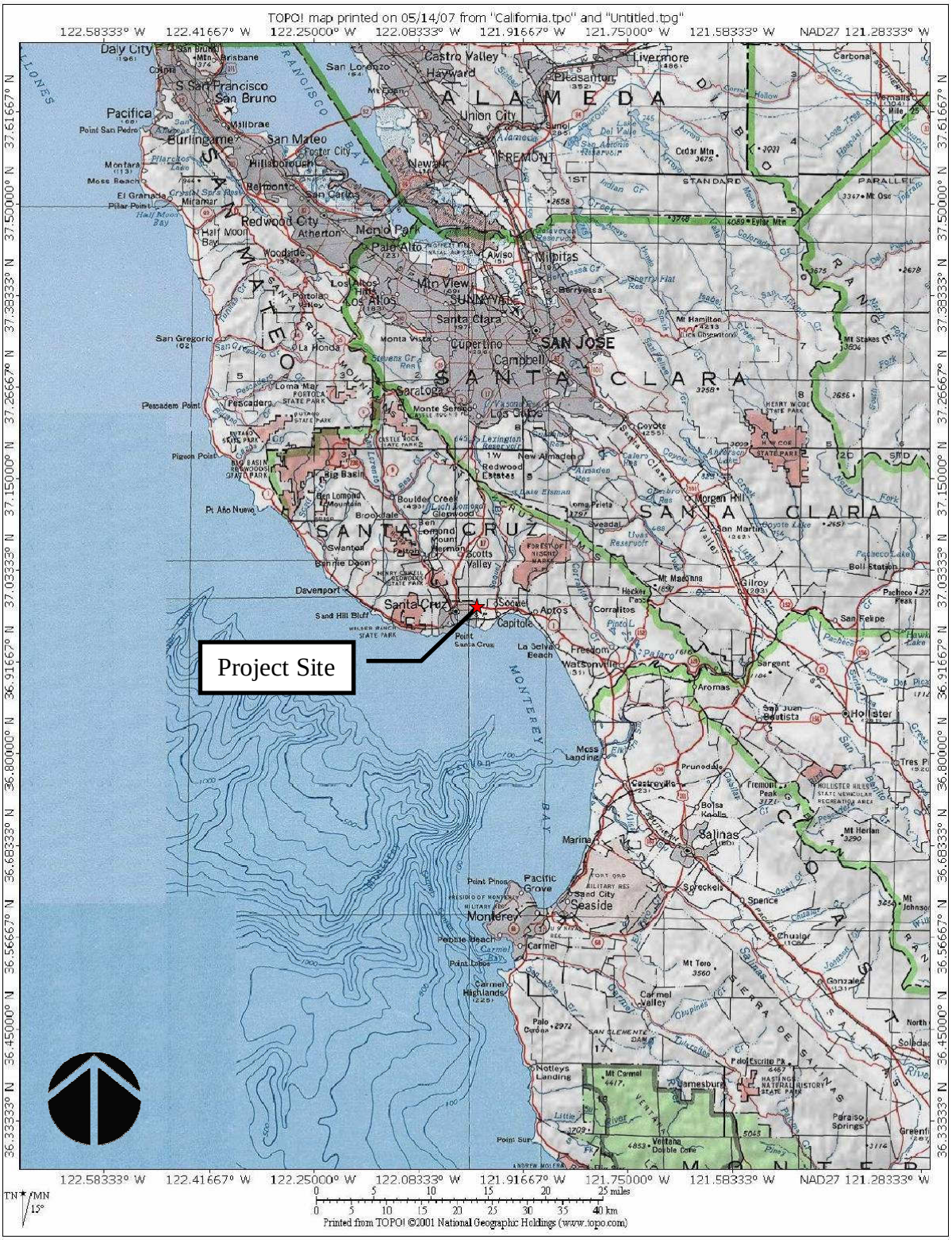

Figure 1. Vicinity Map

Source: United States Geological Survey

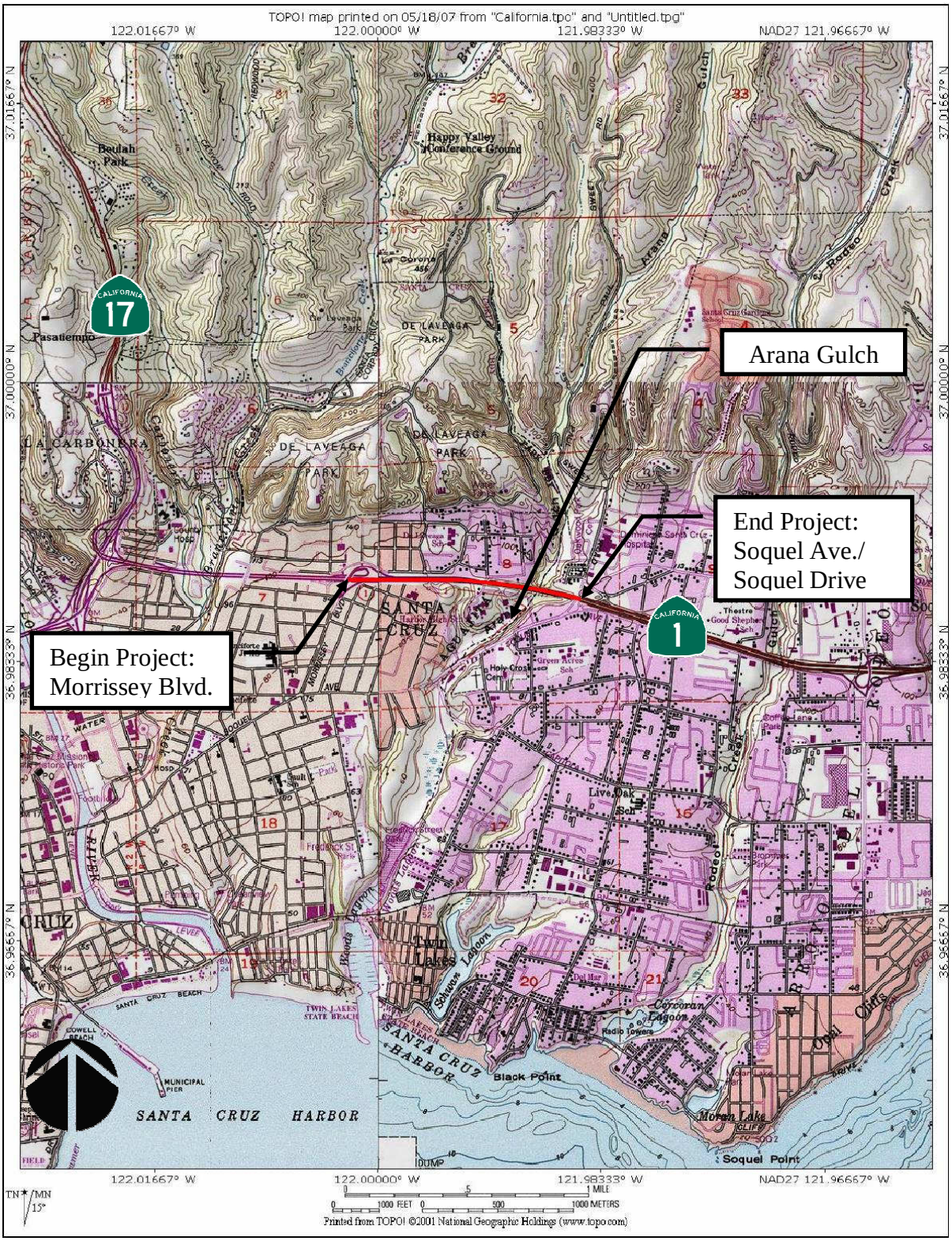

Figure 2. Location Map

Source: United States Geological Survey

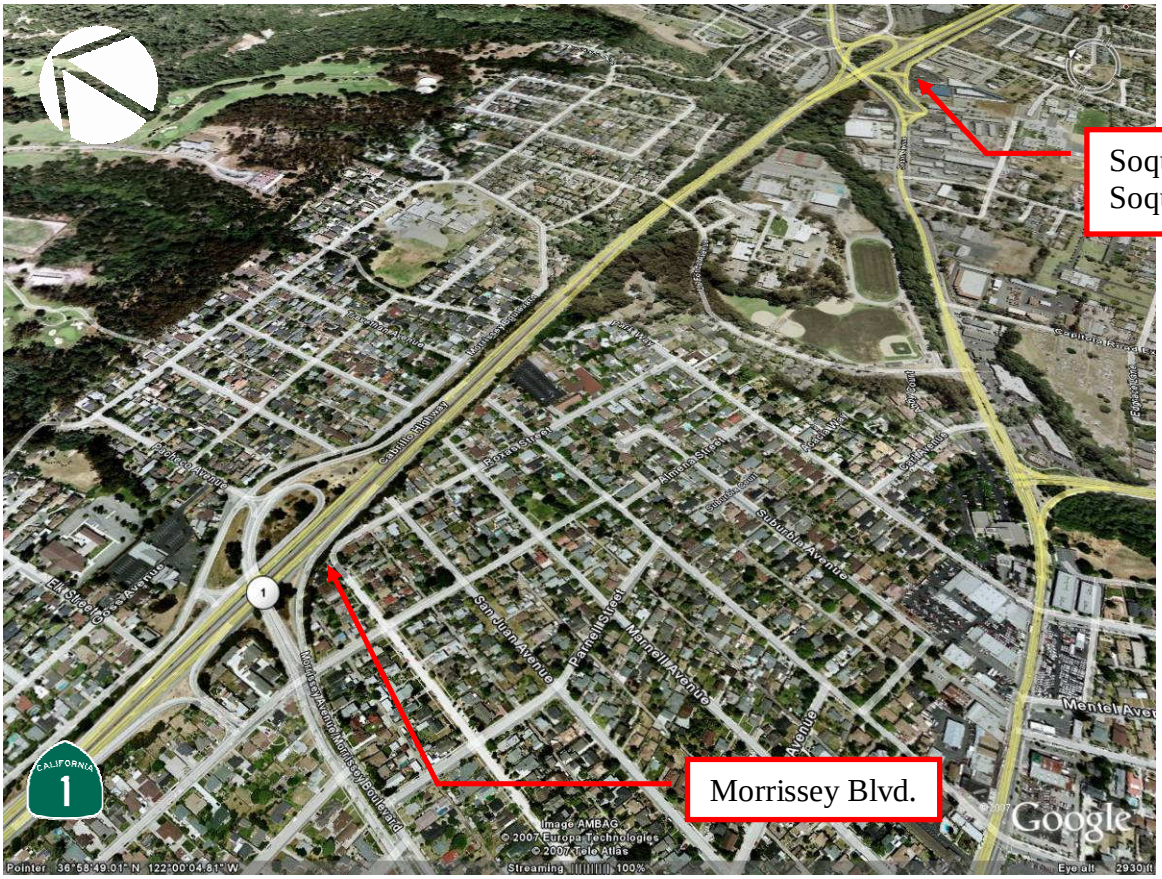

Figure 3. Aerial Map

Source: Google Earth Image (Google Last Accessed: November 16, 2007)

2 FLOODPLAIN DESCRIPTION

2.1 Federal Emergency Management Agency Data

The Federal Emergency Management Agency, Flood Insurance Study, Santa Cruz County, CA and Incorporated Areas (2006), was used to obtain existing floodplain information within the Project area. This Study shows there is a delineated floodplain associated with one of the four crossings within the Soquel to Morrissey Auxiliary Lanes Project limits, at the Arana Gulch crossing (Station 171+03). The water surface elevations upstream and downstream of the Highway 1 crossing were obtained from the Federal Emergency Management Agency Flood Insurance Rate Map; see Appendix B. The existing capacity for the Arana Gulch crossing was determined by comparing the elevation of the roadway with the water surface elevations corresponding to a 100-year peak discharge. The drainage area at the mouth of Arana Gulch is 3.5 square miles (9.1 square kilometers), with a 100-year peak discharge of 1,650 cfs (47 m^3/s). The mouth of Arana Gulch is 1.7 miles (2.7 km) from the Highway 1 crossing (Federal Emergency Management Agency, 1986).

The limits of study of the Flood Insurance Study indicate that there was only a detailed study on Arana Gulch, and not its tributaries. The Flood Insurance Rate Maps do not mention or show the tributaries of Arana Gulch, which further indicates that they were not studied by the Federal Emergency Management Agency for the development of the Flood Insurance Study.

2.2 Map of Floodplain

Based on review of the Federal Emergency Management Agency Flood Insurance Rate Map, one area, within the Soquel to Morrissey Auxiliary Lanes Project limits is within a Federal Emergency Management Agency-delineated floodplain. According to Flood Insurance Rate Map Panel 0351D a floodplain exists at the Arana Gulch crossing with Highway 1. The area within the Project limits is designated as Floodway Areas in Zone AE. These flood insurance rate zones correspond to the 1-percent annual chance floodplains (100-year design storm frequency) that are determined in the Flood Insurance Study (Federal Emergency Management Agency, 2004). The floodplain is depicted as overtopping the roadway at the crossing of Highway 1. The roadway elevation at Highway 1 is shown as 67 ft (20 m) on the Arana Gulch Flood Profile in the FEMA FIS.

The estimated water surface elevations, based on data that are known at this time, is 68 feet (21 m) upstream of the Highway 1 crossing and 49 feet (15 m) downstream of the Highway 1 crossing. These elevations have been converted from the NGVD 29 elevations referenced in the FEMA FIRMs to the NAVD 88 datum referenced in this project (see Section 1.4). The ground elevation at the Arana Gulch crossing is estimated from the project topography as 68 feet (21 m). The base flood elevation and ground elevation is shown to be equal.

2.3 Description of Flood Sources

The mean annual precipitation at the project area is estimated as 30 inches (75 centimeters) and is based on annual precipitation data from the Spatial Climate Analysis Service Parameter-elevation Regressions on Independent Slopes Model Group Internet Map Server (Oregon State University Spatial Climate Analysis, 2007). The rainy season for the project area generally extends from October through May but most flooding occurs from December through March. Westerly exposure to Pacific weather systems promotes intense precipitation from storms. Mountains and hills bordering the eastern boundaries of Santa Cruz County squeeze moisture out of arriving Pacific weather systems and provide watershed areas to funnel precipitation into runoff tributaries.

Early denizens of Santa Cruz County built homes in higher ground, avoiding the floodplains at the lower lying ground areas. Over time, these floodplain areas were developed. High intensity precipitation will likely cause flooding in these lower-lying ground areas. The major drainage basin in the project area is the San Lorenzo River Basin. The drainage basins in Santa Cruz County are short and steep with short flow durations. Flood stage can swell to flood peaks in a few hours with high velocities in the main channel.

Flooding along the Pacific Coast of Santa Cruz County is typically associated with the simultaneous occurrence of very high tides, large waves, and storm swells during the winter. Flood hazards along the coast are generated by swell waves from offshore storms, by wind waves from land-falling storms, and by tsunamis. Other hazards, that present potential damage to structures, exposure to erosion, and impacts to channels, are landslides, earthquakes, and wildland fires. Areas in Santa Cruz County would be significantly impacted by a tsunami created by an earthquake on the San Gregorio fault; the fault is located offshore in Monterey Bay and roughly parallels the coastline. The tsunami created by such an earthquake would arrive without warning, minutes after the initial shock (Federal Emergency Management Agency, 2006). The Highway 1 Soquel/Morrissey Auxiliary Lanes Project reach of Highway 1 is well over one mile (1.57 kilometers) inland from the coast.

These flooding sources have historically had significant impacts on ocean-front development. Direct wave impacts sustained by beachfront homes during the severe storms of January 1978 accelerated erosion and weakened foundations. Seawalls and temporary barriers, intended to protect the beach shoreline, were either damaged or destroyed. In addition, storm centers from the southwest produce storm flow patterns toward the coast that have caused the majority of the serious coastal floods; strong winds and high tides create storm surges that back up river flows and this leads to flooding at the river mouths (Federal Emergency Management Agency, 2006). Woods Lagoon, which is at the mouth of the Arana Gulch drainage, is over one mile (1.57 kilometers) away from Highway 1.

2.4 Hydraulic Assessment

In general, roadways will be inundated if the upstream water surface elevation is greater than the elevation of the roadway. The hydraulic regime for the creek crossings at

Highway 1 is upstream controlled. The Federal Emergency Management Agency *Flood Insurance Study* documents debris buildup and ponding during past severe storm events. Debris buildup and ponding has the potential to occur at the upstream end of the culverts which could attenuate peak flows. Figure 4, entitled *Watershed Map* shows the upstream watershed of Arana Gulch and its three tributaries. The *Watershed Map* only shows the upstream watersheds since only the upstream flows affect the Soquel to Morrissey Auxiliary Lanes Project.

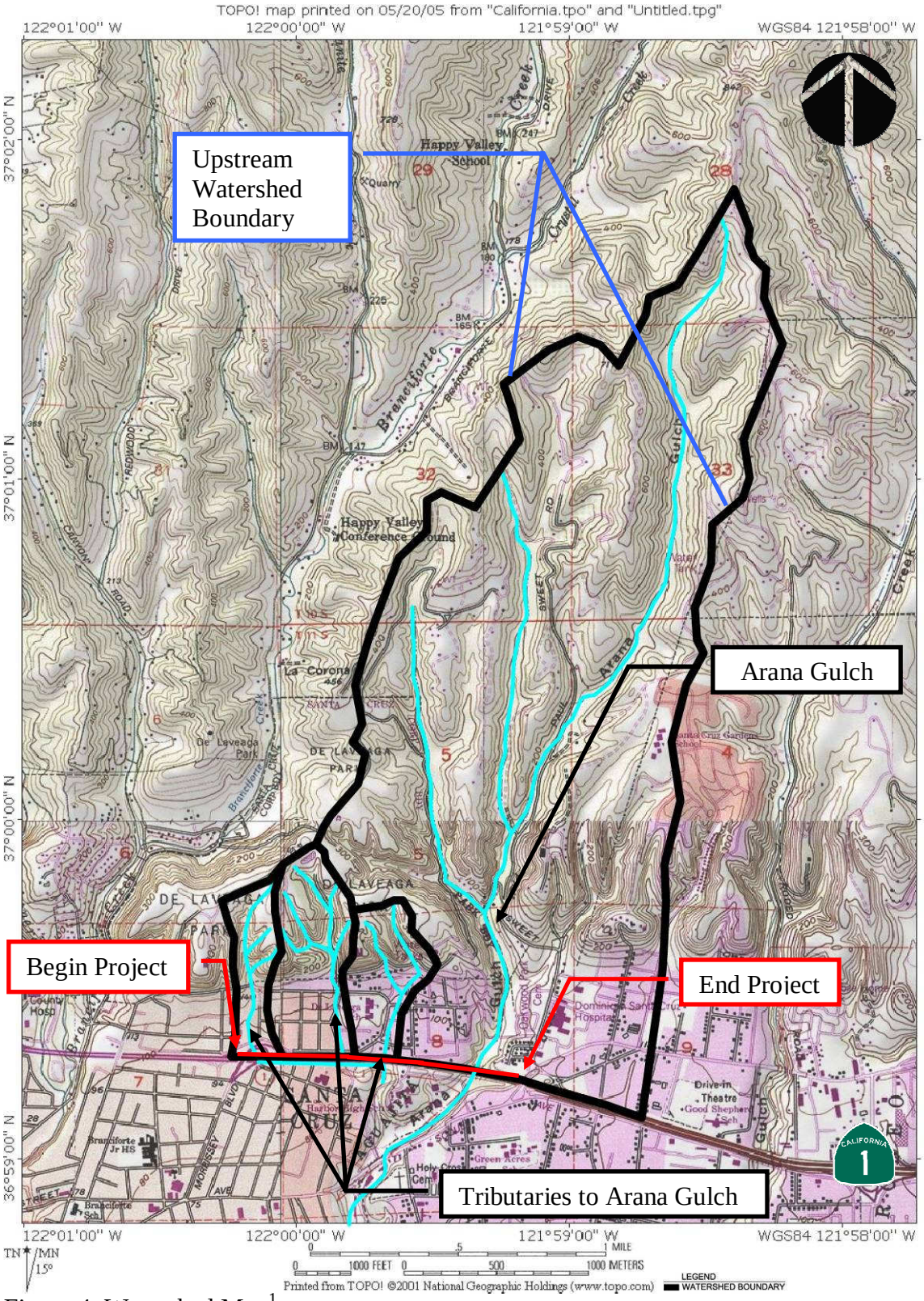

Figure 4. Watershed Map[1]

Source: United States Geological Survey

[1] Note: Figure 4. Watershed Map shows only tributary delineation for flow upstream of the Project.

3 PROJECT EVALUATION

Highway 1 is proposed to be widened in both directions of travel.

Highway 1 is proposed to be widened in the floodplain area associated with Arana Gulch. This widening will occur with the addition of the auxiliary lanes, and associated improvements, in both the northbound and southbound directions of Highway 1. The replacement of the existing overcrossing at La Fonda Avenue and Morrissey Boulevard is beyond the delineated Arana Gulch 100-year floodplain. Parallel culverts are also recommended to be constructed at the tributary to Arana Gulch at Station 177+92 because preliminary calculations indicate that the culvert is undersized. These proposed improvements would be outside the FEMA-delineated floodplains.

There are no available Federal Emergency Management Agency floodplain studies or available historic information for the tributaries to Arana Gulch. Further studies can be done during the design phase of this Project when more detailed surveys are available. Proposed drainage improvements to address Project impacts are discussed in the Drainage Impact Summary Report (2008).

The addition of the auxiliary lanes will result in an increase in impervious surfaces. This will result in increases to peak storm water runoff and reduction in the amount of pervious surfaces available for infiltration of storm water runoff. Table 3 lists the increase in impervious surface area for each creek crossing, in comparison to the off-site watershed area. The percentage increase in area is minimal: 0.6% for all four crossings combined. Arana Gulch is the only creek with an associated floodplain area.

Table 3. Increased Impervious Areas

	Station at Highway 1 Crossing	Increased Impervious Area (acres)	Watershed Areas (acres)	Percentage Increase in Area
Arana Gulch	171+03	1.3	2,239	0.06%
Tributary to Arana Gulch	175+98	0.24	71	0.34%
Tributary to Arana Gulch	177+92	0.21	108	0.20%
Tributary to Arana Gulch	183+01	0	53	0%

3.1 Risk associated with implementation of the action

3.1.1 Evaluation of Project Impacts to Existing Floodplains

The Rational Method was utilized to estimate additional flow from the added paved surfaces of the roadway widening. The added impervious area reaching Arana Gulch was estimated as 5,330 square meters. The intensity at the Arana Gulch crossing of Highway 1 was estimated using the HYDRO module of HYDRAIN as 119 mm/hr for a time of concentration of 5 minutes; see Appendix C. A runoff coefficient of 0.9 adjusted by a frequency factor of 1.25 for a 100-year design storm resulted in an adjusted runoff coefficient of 1.0. The additional flow was estimated as 0.2 cubic meters per second. Thus, the 100-year design discharge for the proposed condition is 47.2 cubic meters per second.

3.1.2 Stream and Site

Arana Gulch is heavily vegetated upstream of the Highway 1 crossing. Arana Gulch is conveyed under Highway 1 through a concrete arch culvert with a height of 1.8 m (6 ft). The span of the culvert was estimated as 1.7 m (5.7 ft). Downstream of the Highway 1 crossing is a concrete lined channel with gravel at the bottom. Arana Gulch crosses Highway 1 at 29° from perpendicular.

3.1.3 Design Tool

The effects of the increased flow resulting from the roadway widening at the Arana Gulch crossing at Highway 1 was evaluated using the Army Corps of Engineers HEC-RAS modeling software (Version 3.1.3). Hydraulic analyses were performed for the existing and proposed conditions.

3.1.4 Cross-Section Data

A total of nine cross sections were cut, distributed over a 150 m reach of Arana Gulch. These cross-sections were based on aerial survey. They are shown in Figure 5. These cross-sections included six which are located upstream of Highway 1 and three which are downstream of the crossing. Highway 1 is located between River Stations 210 and 290.

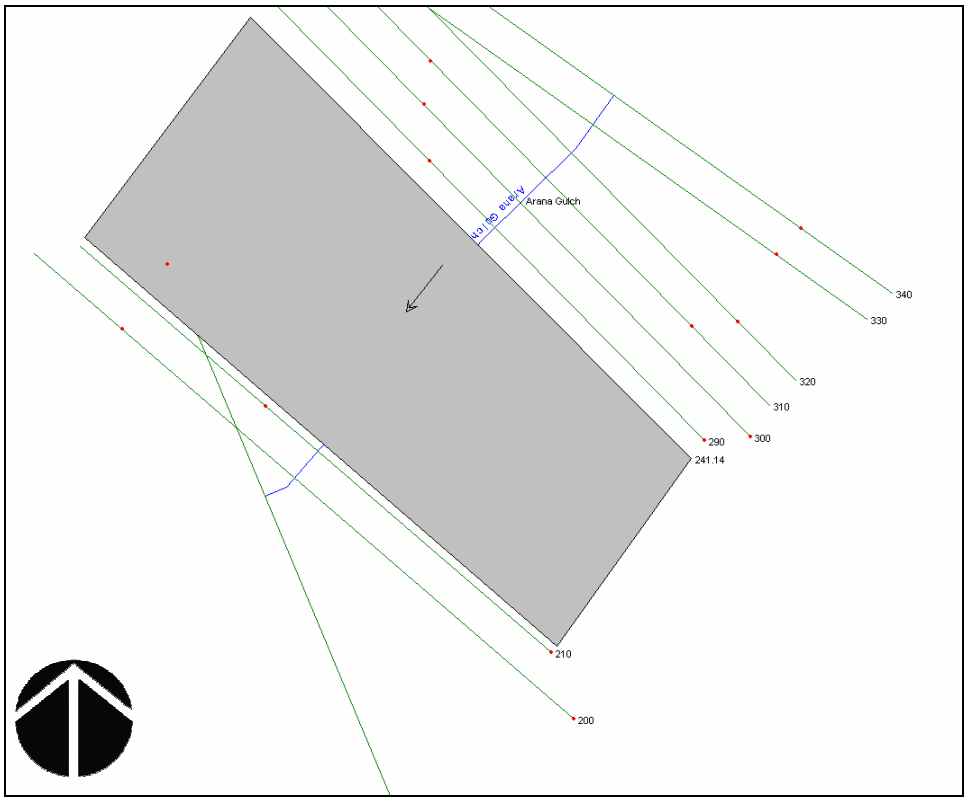

Figure 5. River Station (Cross-Section) Locations for HEC-RAS Models

3.1.5 Manning's "n"

Manning's "n" values were used in the hydraulic model to estimate energy losses in the flow due to friction. The Manning's "n" value for cross-sections upstream of the

Highway 1 crossing was 0.06 to describe friction characteristics of a floodplain with trees. The Manning's "n" value for cross-sections downstream of the Highway 1 crossing was 0.017 for a concrete channel with gravel bottom. These Manning's "n" values were selected based on observations from field visits to the site.

3.1.6 Expansion and Contraction Coefficients

An expansion coefficient of 0.3 and a contraction coefficient of 0.1 were used to represent the creek. These values describe creek geometry with gradual transitions between cross-sections.

3.1.7 Arana Gulch Water Surface Elevations

Design flows for the 100-year storm used in the hydraulic models for the existing and proposed condition are based on design discharge reported by FEMA and estimated additional flow using the Rational Method; see Sections 2.1 and 3.1.1. The design peak flows was 47 cubic meters per second for the existing condition hydraulic analysis and 47.2 cubic meters per second for the proposed condition.

The estimated water surface elevation for the peak discharge at the cross-section immediately upstream of Highway 1 was 20.91 m for both the existing and proposed conditions. The Arana Gulch culvert water surface profiles for both the existing and proposed conditions are shown in Figure 6. The HEC-RAS results indicate that the roadway is overtopped in both the existing and proposed conditions. These analyses confirm the data given in the FEMA FIRM and FIS. See Appendix D for summary output results from the existing and proposed condition models.

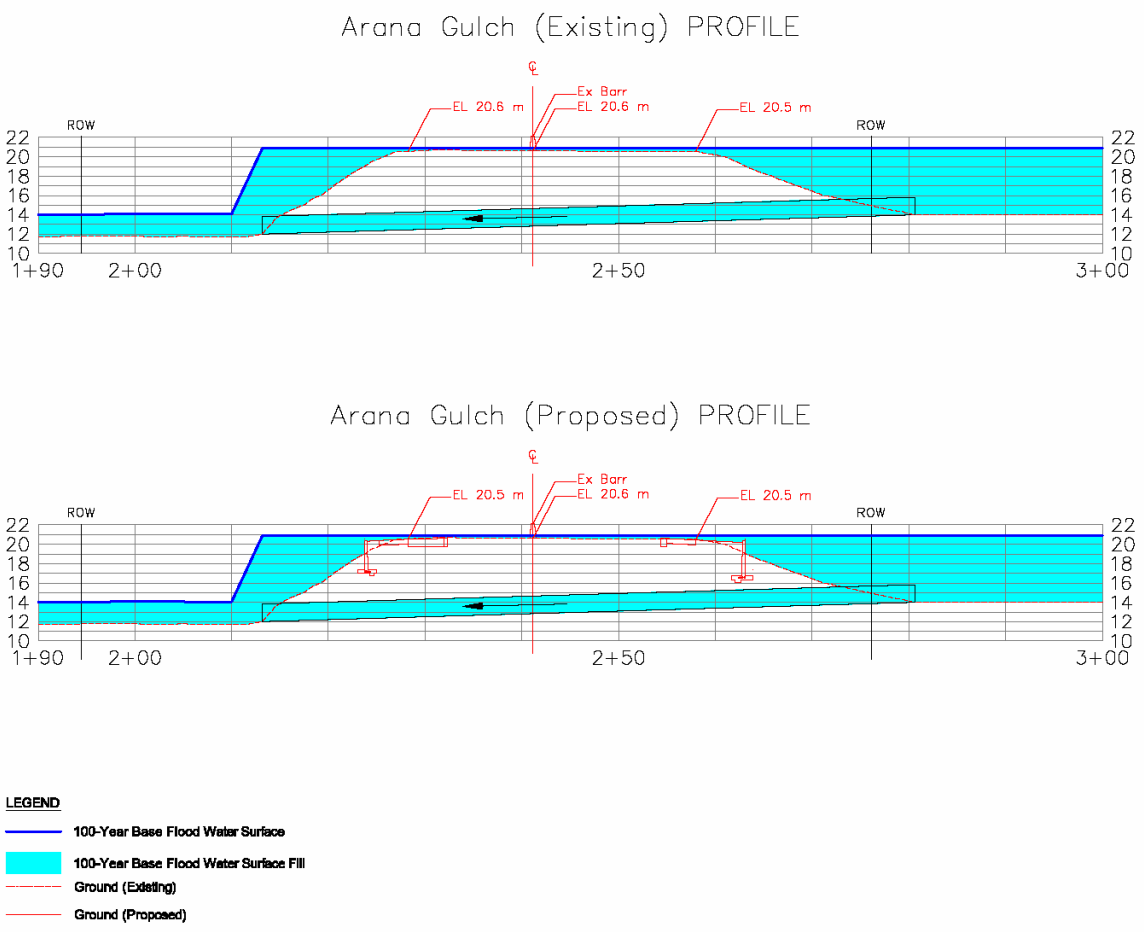

Figure 6. Arana Gulch Existing and Proposed Water Surface Profiles

The Federal Highway Administration (FHWA) defines a "significant encroachment" as a highway encroachment, and any direct support of likely base floodplain development, that would involve one or more of the following construction or flood-related impacts: 1) a significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or provides a community's only evacuation route; 2) a significant risk; or 3) a significant adverse impact on the natural and beneficial floodplain values (1994).

1. The Project does not have a significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or provides a community's only evacuation route. Other local roads and Highway 1 can be utilized for emergency vehicles or as evacuation routes. There may be traffic interruption for the 100-year storm event but traffic at Highway 1 may utilize the local roads for a detour route with access points at the Morrissey Boulevard and Soquel Drive intersections of Highway 1.
2. The level of risk associated with the Project is low. Residential properties north of the crossing (along Oak Way) will be just outside of the base floodplain. Harbor High School south of the crossing will be within the base floodplain in the existing condition. The roadway is overtopped in the existing condition. It is not anticipated that the Project will have significant impacts because the added

impervious areas resulting from the Project will not significantly increase the flow nor raise the water surface elevation of the base floodplain. The slight increase in inundation adjacent to the upstream entrance and downstream outfall would not threaten residential properties.

3. The Project will impact the natural and beneficial floodplain values at Arana Gulch. At this area, designated wetland areas are present in the floodplain areas both upstream and downstream of the Highway 1 crossing. Environmental impacts can be minimized with measures such as revegetation, Best Management Practices, or other requirements anticipated as part of the Project permit conditions.

3.2 Impacts on natural and beneficial floodplain values

Natural and beneficial floodplain values include, but are not limited to: fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and ground water recharge.

The natural and beneficial values for the Arana Gulch and its three tributaries are Army Corps of Engineers (ACOE) wetlands and California Department of Fish and Game (CDFG) jurisdiction. Impacts on natural and beneficial floodplain values being affected for the Soquel to Morrissey Auxiliary Lanes Project for Arana Gulch and its three tributaries are the boundaries referenced in the *Wetlands Assessment Report (2008).* These boundaries are jurisdictional wetlands of the Army Corps of Engineers and the California Department of Fish and Game referenced in the *Wetlands Assessment Report* (2008).

The Army Corps of Engineers definition (1987) reads as follows:

> "The following definition, diagnostic environmental characteristics, and technical approach comprise a guideline for the identification and delineation of wetlands.
>
> a. Definition: The ACOE (Federal Register, Section 328.3(b), 1991) and the EPA (Federal Register, Section 230.4(t), 1991) jointly define wetlands as: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
>
> b. Diagnostic environmental characteristics: Wetlands have the following general diagnostic environmental characteristics:
>
> 1. Vegetation: The prevalent vegetation consists of macrophytes that are typically adapted to areas having hydrologic and soil conditions described in (a) above. Hydrophytic species, due to morphological, physiological, and/or reproductive adaptation(s), have the ability to

grow, effectively compete, reproduce, and/or persist in anaerobic soil conditions.

2. Soil: Soils are present and have been classified as hydric, or they possess characteristics that are associated with reducing soil conditions.

3. Hydrology: The area is inundated either permanently, or periodically at mean water depths <6.6 ft. (~ 2 m), or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation. The period of inundation or soil saturation varies according to the hydrologic/soil moisture regime and occurs in both tidal and non-tidal situations.

c. Technical approach for the identification and delineation of wetlands: Except in certain situations defined in this manual, evidence of a minimum of one positive wetland indicator from each parameter (hydrology, soil, and vegetation) must be found in order to make a positive wetland determination." (California Coastal Commission, 1994).

The Soquel to Morrissey Auxiliary Lanes Project will impact the natural and beneficial floodplain values at Arana Gulch. At this area, designated wetland areas are present in the floodplain areas both upstream and downstream of the Highway 1 crossing. Wetland areas were identified in the *Wetlands Assessment Report* (2008).

A summary of the estimated surface area of natural and beneficial floodplain encroachments is listed in Table 4 for areas upstream and downstream of the Highway 1 crossings. The encroachments represent loss of wetland areas as a result of improvements from the project construction within the Biological Study Area, as delineated in the *Wetlands Assessment Report* (2008).

Table 4. Surface Area of Natural and Beneficial Floodplain Encroachments

Waterway Crossing	Station at Highway 1 Crossing	Total Floodplain Area within BSA and Jurisdictional Areas		Temporary and Permanent Impacts within Floodplains and Jurisdictional Areas				Percent of Affected Floodplain within BSA and Jurisdictional Areas			
		CDFG Jurisdiction	ACOE Wetlands	CDFG Jurisdiction		ACOE Wetlands		CDFG Jurisdiction		ACOE Wetlands	
				Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
		(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)				
Arana Gulch	171+03	8,389	4,451	411	84	0	0	5%	1%	0%	0%
Tributary to Arana Gulch	175+98	0	0	---	---	---	---	---	---	---	---
Tributary to Arana Gulch	177+92	0	0	---	---	---	---	---	---	---	---
Tributary to Arana Gulch	183+01	0	0	---	---	---	---	---	---	---	---

ACOE = Army Corps of Engineers
CDFG = California Department of Fish and Game
BSA = Biological Study Area
--- = No FEMA Floodplain information is available

Habitats for special status species have the potential to occur within the project corridor. The habitats or lack thereof have been determined in the *Draft Natural Environment Study for the Highway 1 Soquel to Morrissey Auxiliary Lanes Project* (2008). This

project will be designed to minimize impacts to Waters of the United States and Waters of the State, including jurisdictional wetlands. Measures to minimize floodplain impacts are discussed in Section 3.4.

3.3 Support of probable incompatible floodplain development

As defined by Federal Highway Administration, the support of incompatible base floodplain development will encourage, allow, serve, or otherwise facilitate incompatible base floodplain development, such as commercial development or urban growth.

Portions of the project site are located on the fringe of the floodplain and there are unavoidable impacts to the floodplain associated with the widening from the construction of the auxiliary lanes. However, as mentioned previously, these impacts are insignificant since the encroachment is minimal; the width of the widening varies from 0.5 m to 8 m. The total area of encroachment in the Arana Gulch floodplain upstream and downstream of the Highway 1 crossing is 90,298 square feet (8,389 square meters) in California Department of Fish and Game jurisdiction wetlands and 4,7910 square feet (4,451 square meters) in Army Corps of Engineers jurisdiction wetlands with no encroachment to the floodplain downstream of the Highway 1 crossing. The added impervious areas will not significantly raise the water surface elevation in the floodplains, and there is ample open space in adjacent undeveloped areas for the floodplain to recreate itself. In addition, new access to developed or undeveloped lands will not be added. Therefore, this project will not support any incompatible floodplain development.

3.4 Measures to minimize floodplain impacts associated with the action

It is important that measures be taken to minimize floodplain impacts. Drainage design improvements are proposed to accommodate increased peak storm water runoff from the roadway. Proposed drainage is discussed in the Drainage Impact Summary Report (2007). In addition, the Soquel to Morrissey Auxiliary Lanes Project design goal will be to maintain pre-construction storm water flows by metering or detaining post-construction flows to pre-construction rates prior to discharge to a receiving water body or Municipal Separate Storm Sewer System. Retaining walls are proposed adjacent to the widening to minimize the encroachment into these Environmentally Sensitive Areas. The proposed retaining wall near and at the north end of the Arana Gulch crossing will be within the 100-year base floodplain. In order to address the impacts from the loss of floodplain storage, mitigation measures are proposed that may be accomplished by re-grading adjacent to the floodplain. Appropriate Best Management Practices are proposed to minimize storm water quality impacts by reducing storm water runoff velocities and promoting infiltration both temporarily, during construction, and permanently.

According to the Caltrans National Pollutant Discharge Elimination System permit and Construction General Permit, Best Management Practices will be incorporated into the contract documents of this project to reduce the discharge of pollutants temporarily, during construction, and permanently to the Maximum Extent Practicable. The Caltrans

Storm Water Handbooks, including the 2007 Project Planning and Design Guide, provide guidance for evaluating projects to determine the need for and feasibility of Construction Site Best Management Practices, Design Pollution Prevention Best Management Practices, and Permanent Treatment Best Management Practices.

Construction Site Best Management Practices are implemented during construction activities to reduce pollutants in storm water discharges throughout construction. Design Pollution Prevention Best Management Practices are permanent measures to improve storm water quality by reducing erosion, stabilizing disturbed soil areas, and maximizing vegetated surfaces. Treatment Best Management Practices are permanent devices and facilities that treat storm water runoff. These Best Management Practices are detailed in the *Storm Water Data Report* (2008).

Mitigation for Wetlands and Waters of the United States impacts will be addressed through consultation with appropriate regulatory agencies. Short term impacts are generally from construction activities such as grading work or dewatering. Temporary Best Management Practices will be considered for this project to prevent potential water quality degradation during construction. Long term impacts from the Soquel to Morrissey Auxiliary Lanes Project could result from floodplain and wetland fill, and potential increases to velocity and volume of downstream flows due to added impervious areas. Storm water runoff from the Highway 1 corridor has the potential to carry pollutants into natural flowing streams as well as into adjacent jurisdictional biotic/aquatic areas. Permanent Best Management Practices will be considered to address these impacts and try to reduce erosion and collect and treat roadway runoff.

The following is a list of Permanent Treatment Best Management Practices that are considered for this project:

- Infiltration Devices
- Biofiltration Strips and Wet Basins
- Biofiltration Swales and Austin Sand Filters
- Detention Devices, Delaware Filters, and Multi Chambered Treatment Trains

Best Management Practices that are feasible for this project include Biofiltration Strips, Biofiltration Swales, and Detention Devices. The other Treatment Best Management Practices were considered not feasible due to but not limited to site restrictions, limited right-of-way, protection of wetlands or vegetation, limited hydraulic head.

3.5 Measures to restore and preserve the natural and beneficial floodplain values impacted by the action

The Soquel to Morrissey Auxiliary Lanes Project will result in a loss of wetland area and loss of vegetation (see Section 3.2). Environmental impacts will be a result of construction activities and can be minimized with measures such as revegetation, Best Management Practices, or other requirements anticipated as part of the Soquel to Morrissey Auxiliary Lanes Project permit conditions. Refer to the biological assessment report for this project for proposed wetland mitigation measures.

The Santa Cruz County Regional Transportation Commission should obtain, as necessary, permits or approvals from or consultation with the United States Army Corps of Engineers, California Department of Fish and Game, the United States Fish and Wildlife Service, the Regional Water Quality Control Board, and the National Oceanic and Atmospheric Administration National Marine Fisheries Service.

3.6 Practicability of alternatives to any significant encroachment

As defined by the Federal Highway Administration, risk shall mean the consequences associated with the probability of flooding attributable to an encroachment. It shall include the potential for property loss and hazard to life during the service life of the bridge and roadway. The increase in risk associated with the Soquel to Morrissey Auxiliary Lanes Project is negligible.

The Soquel to Morrissey Auxiliary Lanes Project will maintain the existing roadway profile. Effects to the floodplain will be minimal due to the minimal encroachment and negligible increase to the water surface elevation. Storm drainage systems will be upsized, as necessary, to accommodate increased roadway runoff from the roadway improvements.

3.7 Practicability of alternatives to any longitudinal encroachment

As defined by the Federal Highway Administration, a longitudinal encroachment is an action within the limits of the base floodplain that is longitudinal to the normal direction of the floodplain.

A longitudinal encroachment is "[a]n encroachment that is parallel to the direction of flow. Example: A highway that runs along the edge of a river is, usually considered a longitudinal encroachment." The requirement for consideration of avoidance alternatives must be included in a Location Hydraulic Study by including an evaluation and a discussion of the practicability of alternatives to any significant encroachment or any support of incompatible floodplain development.

This project is perpendicular to the direction of flow (a transverse encroachment) and is, therefore, not considered a longitudinal encroachment to the 100-year floodplains. Therefore, alternatives are not considered.

3.8 Coordination with Local, State, and Federal Water Resources and Floodplain Management Agencies

Gregor Blackburn, Senior Natural Hazards Program Specialist with the Federal Emergency Management Agency, and Jessica DeGrassi, Resource Planner for the Santa Cruz County Planning Department, were contacted to discuss project impacts to the watershed and floodplain. Due to the encroachment on the regulatory floodways, the Santa Cruz County Planning Department will review this report to determine if a floodplain map revision is necessary. A revision is not anticipated since the increase in

the base flood plain elevation is minimal. Upon circulation of the final Environmental Document, copies will be distributed to the Santa Cruz County Planning Department.

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Appendix A Summary of Floodplain Encroachment

FLOODPLAIN EVALUATION REPORT SUMMARY

Dist. 05 Co. SCR Rte. 01 K.P. _____
Project No.: _____ Bridge No. _____
Limits: Concrete arch culvert crossing at Arana Gulch _____

Floodplain Description: 100-year flood will not be contained in Arana Gulch _____

		No	Yes
1.	Is the proposed action a longitudinal encroachment of the base floodplain?	X	
2.	Are the risks associated with the implementation of the proposed action significant?	X	
3.	Will the proposed action support probable incompatible floodplain development?	X	
4.	Are there any significant impacts on natural and beneficial floodplain values?	X	
5.	Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain.	X	
6.	Does the proposed action constitute a significant floodplain encroach-ment as defined in 23 CFR, Section 650.105(q).	X	
7.	Are Location Hydraulic Studies that document the above answers on file? If not explain.		X

PREPARED BY:

Signature - Hydraulic Engineer — Date: 9/16/2008

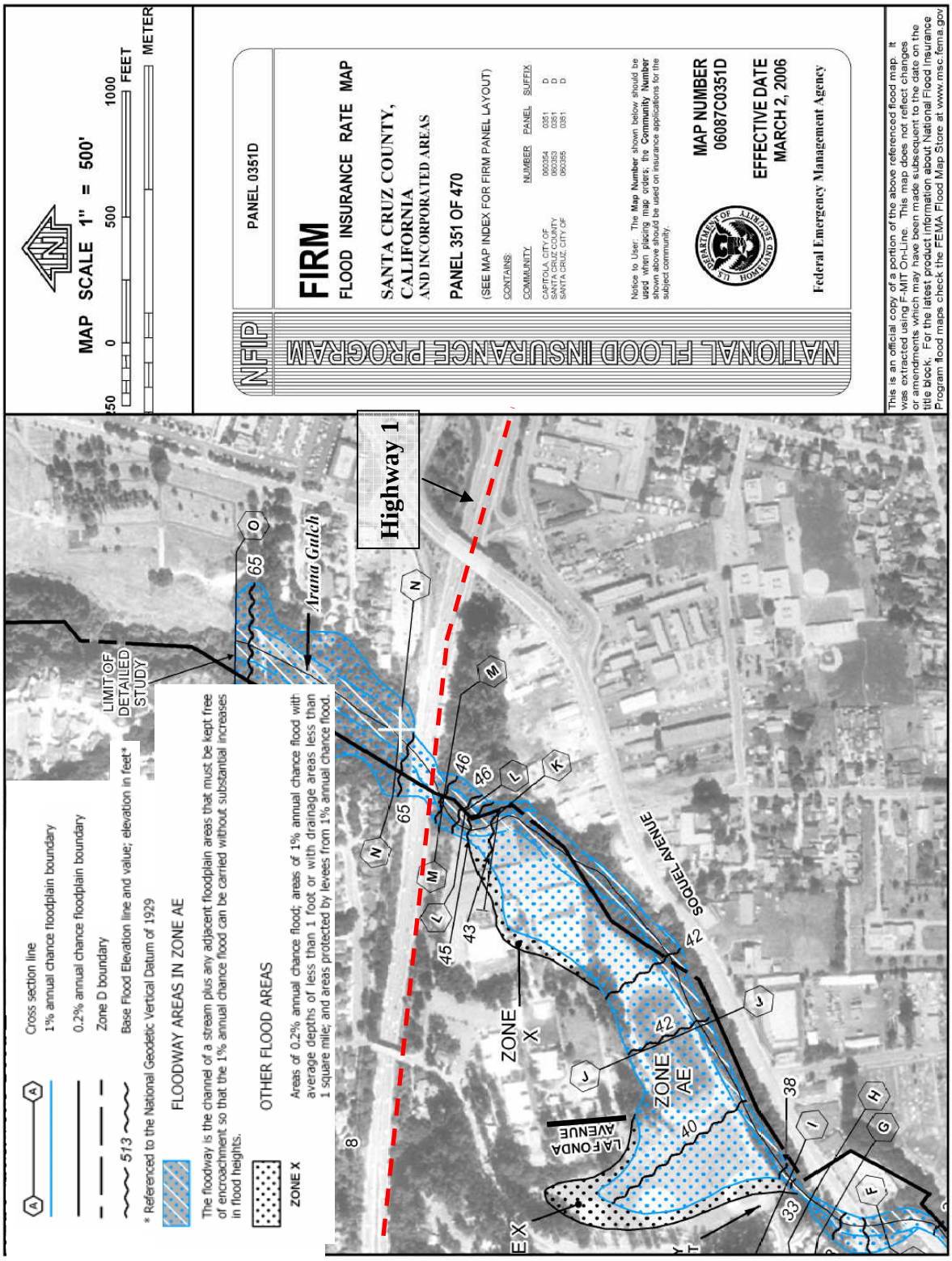
CONCURRENCE BY:

Signature - Dist. Hydraulic Engineer — Date: 9/24/08

Signature - Dist. Environmental Branch Chief — Date: 9/25/08

Signature - Dist. Project Engineer — Date: 9/25/08

Appendix B Federal Emergency Management Agency – Arana Gulch 100-Year Floodplain Flood Insurance Rate Map


NFIP
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
SANTA CRUZ COUNTY, CALIFORNIA AND INCORPORATED AREAS
PANEL 351 OF 470
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
PANEL 0351D
MAP NUMBER 06087C0351D
EFFECTIVE DATE MARCH 2, 2006
Federal Emergency Management Agency
MAP SCALE 1" = 500'
Highway 1
Arana Gulch
SOQUEL AVENUE
LA FONDA AVENUE
ZONE X
ZONE AE
LIMIT OF DETAILED STUDY
Cross section line
1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Zone D boundary
Base Flood Elevation line and value; elevation in feet*
* Referenced to the National Geodetic Vertical Datum of 1929
FLOODWAY AREAS IN ZONE AE
The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.
OTHER FLOOD AREAS
ZONE X
Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

Appendix C Intensity-Duration-Frequency Curve

```
               *************** HYDRO - Version 6.1 ***************
               *  HEC19 / Design Event vs Return Period Program  *
               *              Date of Run: 04-03-2008            *
                                                                  Page No  1
                              Highway 1 Arana Gulch

--- Input File: C:\HYDRO\ARANA.HDO

 IDF

 === IDF CURVE Option Selected ...

 CAL rain95.asc

 === File Read from Intermediate Directory: rain95.asc

 RPD 25

--- The Selected Return Period is   25 years.

 LOC 36 59 121 59

--- The Latitude is 36 degrees, 59 minutes.
--- The Longitude is 121 degrees, 59 minutes.

 STA
 STA
 STA

*** End of Command File



--- The Following Station(s) Will Be Used in Determining the Sites Intensity:
    Station ID   Elev. (m)   Lat/Long (dec. deg.)  Distance from Site (km)

    D007616050     18           36.967  121.967               .000

    Notice:  A Station Elevation of -999 Indicates A Missing Value.


                 ***** HYDRO ***** (Version 6.1) *****         Date 04-03-2008
                                                                  Page No  2
                              Highway 1 Arana Gulch

                        -----------------------------------
                        IDF Curve for Various Return Periods
                        -----------------------------------
                              Intensities (mm/h)

 Duration       25 Yr     2 Yr      10 Yr      50 Yr     100 Yr   10000 Yr
 ------------------------------------------------------------------------------
  5 min          96.        47.        80.       108.       119.       188.
 10 min          70.        34.        58.        78.        86.       137.
 15 min          58.        28.        48.        65.        72.       113.
 30 min          42.        21.        35.        47.        52.        82.
 60 min          31.        15.        25.        34.        38.        60.
120 min          22.        11.        18.        25.        28.        44.
  4 h            16.         8.        13.        18.        20.        32.
  8 h            12.         6.        10.        13.        15.        23.
 16 h             9.         4.         7.        10.        11.        17.
 24 h             7.         3.         6.         8.         9.        14.
 ------------------------------------------------------------------------------
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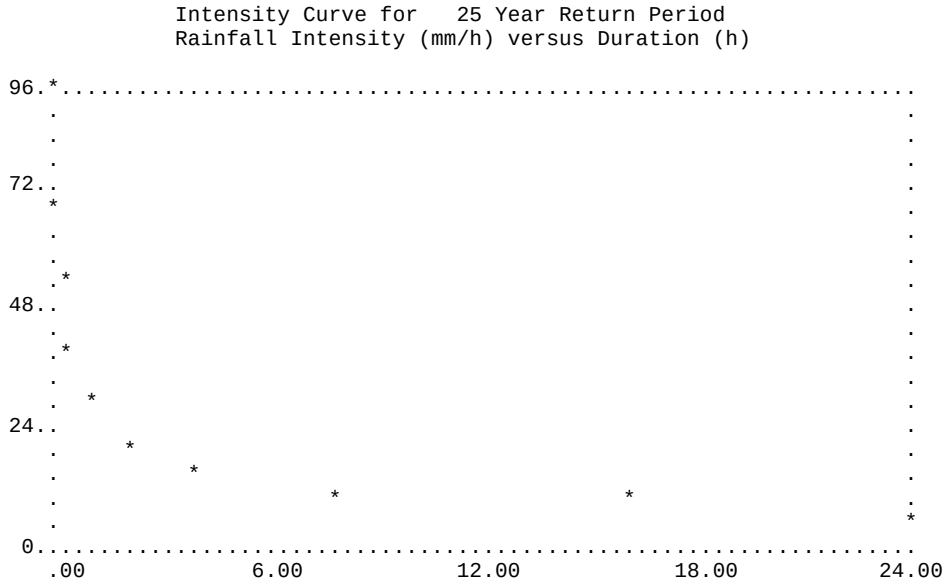

***** HYDRO ***** (Version 6.1) ***** Date 04-03-2008
Page No 3

Highway 1 Arana Gulch

+++ Notice: Intermediate file has SI units.

=== File Created on Intermediate Directory: ARANA.IDF

+++ NORMAL END OF HYDRO

Appendix D HEC-RAS Summary Tables

Summary Table – Existing Condition

HEC-RAS Plan: Existing River: Arana Gulch Reach: Arana Gulch Profile: Q100

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Arana Gulch	340	Q100	47.00	14.00	20.91	14.32	20.91	0.000001	0.06	739.11	125.16	0.01
Arana Gulch	330	Q100	47.00	14.00	20.91		20.91	0.000002	0.07	714.14	126.13	0.01
Arana Gulch	320	Q100	47.00	14.00	20.91		20.91	0.000002	0.08	610.92	114.57	0.01
Arana Gulch	310	Q100	47.00	14.00	20.91		20.91	0.000003	0.09	540.97	99.86	0.01
Arana Gulch	300	Q100	47.00	14.00	20.91		20.91	0.000005	0.11	434.70	84.83	0.02
Arana Gulch	290	Q100	47.00	14.00	20.91	14.82	20.91	0.000012	0.16	302.53	65.01	0.02
Arana Gulch	241.14		Culvert									
Arana Gulch	210	Q100	47.00	11.74	14.06		14.16	0.000641	1.37	34.34	37.86	0.46
Arana Gulch	200	Q100	47.00	11.61	14.10		14.13	0.000207	0.80	58.77	62.93	0.26
Arana Gulch	190	Q100	47.00	11.56	14.00	12.96	14.12	0.000376	1.54	30.49	18.01	0.38

Summary Table – Proposed Condition

HEC-RAS Plan: Proposed River: Arana Gulch Reach: Arana Gulch Profile: Q100

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Arana Gulch	160	Q100	47.20	14.00	20.91	14.33	20.91	0.000001	0.06	739.43	125.17	0.01
Arana Gulch	150	Q100	47.20	14.00	20.91		20.91	0.000002	0.07	714.46	126.14	0.01
Arana Gulch	140	Q100	47.20	14.00	20.91		20.91	0.000002	0.08	611.21	114.58	0.01
Arana Gulch	130	Q100	47.20	14.00	20.91		20.91	0.000003	0.09	541.23	99.87	0.01
Arana Gulch	120	Q100	47.20	14.00	20.91		20.91	0.000005	0.11	434.92	84.84	0.02
Arana Gulch	110	Q100	47.20	14.00	20.91	14.82	20.91	0.000012	0.16	302.70	65.03	0.02
Arana Gulch	61.14		Culvert									
Arana Gulch	30	Q100	47.20	11.74	14.06		14.16	0.000645	1.37	34.36	37.88	0.46
Arana Gulch	20	Q100	47.20	11.61	14.10		14.13	0.000209	0.80	58.83	62.99	0.27
Arana Gulch	10	Q100	47.20	11.56	14.00	12.96	14.12	0.000379	1.55	30.49	18.01	0.38

Appendix E Project Photographs

Photo 1. Tributary to Arana Gulch (Station 177+92) at Holway Drive crossing

Photo 2. Tributary to Arana Gulch (Station 175+98)

Photo 3. Arana Gulch (Station 171+03) downstream of Highway 1 crossing

Photo 4. Arch culvert at Arana Gulch (Station 171+03) downstream of Highway 1 crossing

Photo 5. Arch culvert at Arana Gulch (Station 171+03) downstream of Highway 1 crossing